

THE PHENOLOGY OF *CYDIA SUCCEDANA* ON GORSE IN CANTERBURY

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ABSTRACT

The phenology of *Cydia succedana*, an introduced seed-feeder of *Ulex europaeus*, was investigated. Pheromone traps were set out at McLeans Island, Christchurch, a warm, lowland site and Hinewai Reserve, Banks Peninsula, a cool, upland site, to observe the phenology of *C. succedana* at two different altitudes and climatic conditions. Moth populations were estimated by the mean number of male moths caught in the traps. The phenology of *C. succedana* was synchronised with the first *U. europaeus* flowering in spring-summer. Significantly more male moths were captured at McLeans Island from October 2002 to February 2003.

Keywords: *Ulex europaeus* gorse, *Cydia succedana*, gorse pod moth, phenology, pheromone trap.

INTRODUCTION

Gorse (*Ulex europaeus* L.) was introduced into New Zealand before 1835 as a fast-growing hedge plant (Moss 1960). Gorse has multiplied and dispersed rapidly, and many seeds, which can remain viable for at least 40 years, have become deposited in the soil seed bank (Zabkiewicz 1976). Gorse plants require about 18 months of growth and development before they flower. In cooler climates, e.g. the Mackenzie Basin, flowering occurs only once a year, in the spring (Hill et al. 1991). However, in warmer climates, e.g. Golden Bay, there is a second flowering, producing a lower seed yield in autumn (Cowley 1983).

Larvae of *Cydia succedana* (Denis & Schiffermüller) (Lepidoptera: Olethreutidae) live within gorse pods. Each larva can consume the seed of a number of pods (Hill & Gourlay 2002; Sixtus 2004). For this seed destruction to occur, the phenology of *C. succedana* must coincide with gorse seed production. Because the gorse seed weevil, *Exapion ulicis* (Förster) has only one generation in New Zealand that targets gorse seed produced in the spring and leaves autumn-produced seed unattacked, the synchrony of *C. succedana* with the second gorse flowering is important in reducing the total amount of seed produced.

As a first step to assess the effectiveness of the gorse pod moth in New Zealand, it was necessary to study the phenology of both the moth and gorse. Gorse phenology in New Zealand varies greatly with climate, altitude and aspect (Hill et al. 1991). Previous studies of the genus *Cydia* found that development rate was also modified by several factors, including photoperiod and altitude, but it was primarily controlled by temperature (Hughes et al. 2004). It was assumed that *C. succedana* would follow this pattern.

Suckling et al. (1999) found that male *C. succedana* moths were trapped in pheromone traps when the bait was female sex pheromone. Traps were an effective method of detecting the presence of the moth, and therefore this method was used in the current study. The aim of this study was to compare *C. succedana* phenology in a warm, dry area (McLeans Island, Christchurch) with that in a cool, wet area (Hinewai Reserve, Banks

Peninsula), using pheromone traps. The data were used to assess the synchronicity of adult moth abundance and plant phenology.

MATERIALS AND METHODS

Sampling sites

Sampling began on 6 March 2002 at McLeans Island (43° 27.99' S 172° 28.97' E, 60.2 m above sea level) and on 8 March 2002 at Hinewai (43° 48.62' S 173° 01.67' E, 469 m above sea level). The daily minimum and maximum air temperature and daily rainfall were recorded by a thermohygrograph from March 2002–March 2003 using dedicated apparatus at the National Institute of Water & Atmosphere (NIWA) weather station at Christchurch International Airport for nearby McLeans Island, and a weather station (Hinewai). Monthly average temperature was calculated from the records.

At McLeans Island, gorse bushes had spread intermittently into pasture but were stunted and had dead branches. Height (0.81 ± 0.3 m) of gorse bushes was limited, probably due to low rainfall and attack by several biological control agents, particularly a gorse stem miner (*Anisopla ptyoptera* Meyrick). At Hinewai the gorse was very dense and not controlled chemically or mechanically (height 1.41 ± 0.6 m). There was no indication of the presence of *A. ptyoptera* at Hinewai Reserve. Hinewai Reserve has been a reserve since 1987 and there has been no mechanical or chemical control since then. At McLeans Island there was no indication of either chemical or mechanical controls being used. There is no record of when the last spraying of gorse took place (B. Dimpleby, pers. comm.).

Cydia succedana trapping

Five pheromone traps were set out randomly at each site along a transect. The traps were supplied by HortResearch, Auckland, New Zealand, and were baited with (E, E)-8, 10-dodecadien-1-yl acetate, which attracts only male moths (Suckling et al. 1999). Traps were checked at weekly to monthly intervals, depending on moth activity. When moths were active, the sticky bases in each pheromone trap were changed weekly. At other times, they were changed every 2–4 weeks. Pheromone caps were changed every 6 weeks as recommended by HortResearch.

The number of moths caught on each pheromone trap base was recorded each time the base was removed. Data were converted into mean number of moths caught per trap per day.

Gorse phenology

As part of the study of the biological control of gorse, the phenological stage of the gorse plants was visually estimated at each monthly visit to the sites (% of plants in buds, flowers, green pods or black pods, to the nearest 5%). If the estimate was below 5%, the condition was recorded as zero. Fifteen gorse bushes were randomly selected along a transect at each site. The estimate was made of the whole gorse bush. No black pods were produced at McLeans Island over the 13 months of monitoring, possibly due to dry conditions and the gorse being attacked by several biological control agents.

Data collection and analysis

Least Significant Differences were calculated using the Greenhouse-Geiser method for ANOVA from repeated measures.

RESULTS

Seasonal activity of *Cydia succedana*

Significantly ($P < 0.05$) more moths were caught at McLeans Island compared with Hinewai at every trap collection date from October 2002 to the end of February 2003, with the exception of 3 January 2003 (Fig. 1). There was no significant difference in moth numbers ($P > 0.05$) between the two sites between 27 March 2002 and 17 September 2002 or during March 2003 (Fig. 1).

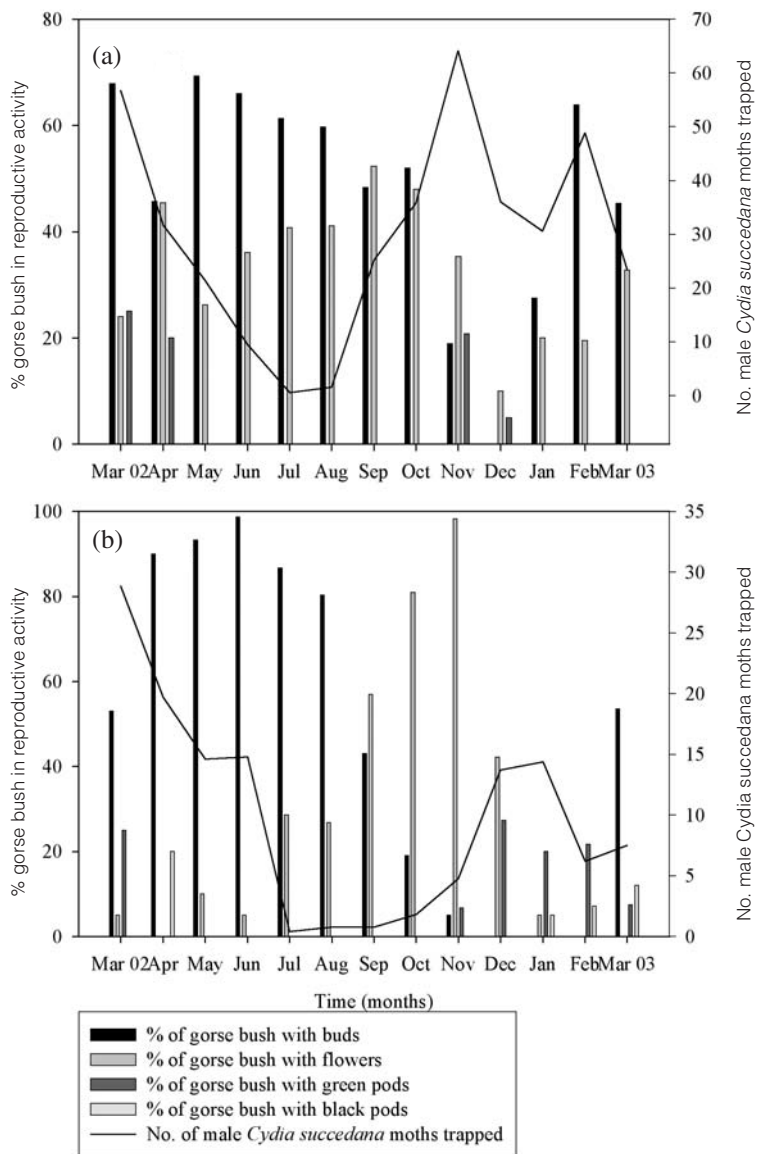


FIGURE 1: The estimated monthly percentage of gorse bushes in reproductive stages (buds, flowers, green pods or black pods) and the mean number of male gorse pod moths recovered/pheromone trap/day from March 2002 to March 2003 at (a) McLeans Island and (b) Hinewai Reserve. The LSD ($P < 0.05$) for repeated measures ANOVA for the Date \times Site interaction of male gorse pod moth numbers was 1.3.

Weather records

During the 13 months of the study, total rainfall at McLeans Island was 574 mm (Christchurch Airport) (E. Fouhy, NIWA, pers. comm.). At Hinewai, total rainfall was 1512 mm (H. Wilson, pers. comm.). McLeans Island mean daily maximum and minimum temperatures were significantly higher ($P < 0.0001$) than at Hinewai (Fig. 2).

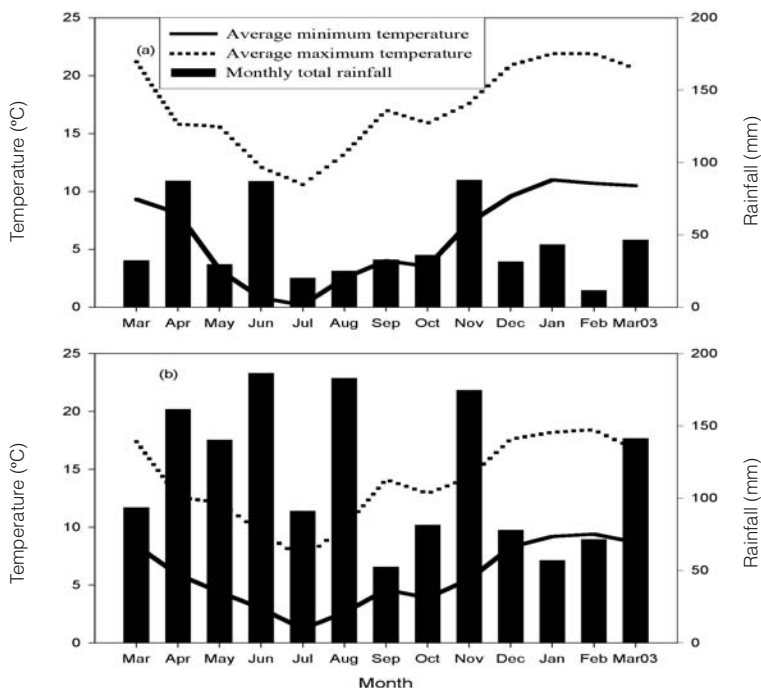


FIGURE 2: The monthly mean maximum and minimum air temperatures (°C) and monthly total rainfall (mm) from March 2002 to March 2003 at (a) McLeans Island and (b) Hinewai Reserve.

Gorse flowering activity

Gorse flowering differed between sites (Fig. 1). At McLeans Island most bushes were in flower by 17 September 2002; remaining plants had buds that were about to open. Flowering at Hinewai did not reach this level until 14 October 2002. In November, at McLeans Island 20% of plants had green pods but only 5% had green pods at Hinewai. At McLeans Island, no blackened, mature gorse pods were produced in 2002–2003. At Hinewai the first blackened pods were observed in January 2003 and the main production of black pods did not begin until February–March 2003. At McLeans Island, a second generation of buds and flowers was produced during February and March 2003, but this second flowering did not occur at Hinewai.

DISCUSSION

The purpose of this study was to observe the effect of weather, along with different altitudes and soil types on the seasonal activity of *C. succedana* and gorse. Suckling et al. (1999) earlier found that position on a hillside at Darfield (280–370 m altitude) affected gorse phenology with pod numbers peaking in autumn at the top and in spring at the bottom of the hill. In this study a similar pattern was observed with gorse phenological activity occurring earlier at the lower altitude of McLeans Island (Fig. 1).

Bradley et al. (1979) found that in the southern British Isles *C. succedana* is bivoltine. The first generation appears in the spring and the second in the autumn. However, in Scotland *C. succedana* is univoltine, and adult flight only occurs in spring and summer. Suckling et al. (1999) suggested an indication of overlap between generations. Although there is limited information in the current study, there is an indication of two generations per year, with some overlapping. Hinewai had a cool temperate, wet climate whereas McLeans Island had a warm temperate, dry climate, and there was a corresponding difference in the number of male moths trapped (Fig. 1). Indications suggest that the climate was influencing these variables but there may have been other factors involved, such as soil type and altitude.

The threshold temperature for development of eggs of the genus *Cydia* is approximately 10°C (Rock & Shaffer 1983). In a limited study, the lower threshold temperature of *C. succedana* eggs and larvae was 11.5°C (Sixtus 2004). With the exception of June, the McLeans Island daily average maximum and minimum temperature was higher than at Hinewai (Fig. 2). In June, the average maximum temperature was below the lower development threshold of 11.5°C (Sixtus 2004), therefore there would have been little development of *C. succedana* eggs or larvae, and limited adult moth activity. The site difference in daily average temperature may also have influenced the number of male moths caught in the pheromone traps. The number of male moths was always higher at McLeans Island than at Hinewai. Flying insects have a minimum lower threshold temperature for flight that is higher than the developmental temperature threshold, e.g. the lower development threshold for *Cydia pomonella* egg development was 7.5°C (Danthanarayana 1975) and the adult flight minimum temperature was 13°C (Alston & Reding 2003).

A limited study found that *C. succedana* took 588 day-degrees to develop from egg to pupa, which was higher than previous results obtained for other genus *Cydia* species (Sixtus 2004). Moths were active throughout the winter at McLeans Island, although there was a period where activity was low (July–August) (less than 1 moth/trap/day). At Hinewai male moth activity was low for a longer period (July–November) than at McLeans Island. This may have been due to either a lower moth population and/or less activity. Trap catches indicated that *C. succedana* adult numbers increased at McLeans Island in September when the monthly average maximum temperature was 17°C. In contrast, the moth population at Hinewai was low until November (average maximum temperature 14.3°C) and moth population did not peak until January 2003.

At Darfield, Suckling et al. (1999) recorded two peaks of moth activity, suggesting two generations/year. The first peak was in early November and was closely synchronised with spring gorse seed production. Although there was low moth abundance in late November, some moths were present, which indicated an extended generation. The second generation peaked in February, which was before the bulk of autumn pod production in March. In the present study, spring gorse flowering was synchronised with the presence of *C. succedana* at both sites. There was less synchronisation with moth flights and flowering in the second generation at McLeans Island. There was no second flowering generation at Hinewai. In a less intensive study conducted concurrently in Golden Bay, there was synchronization between *C. succedana* and gorse reproduction, especially in the second generation of both the gorse and *C. succedana* (Sixtus 2004).

These results show synchronisation between gorse flowering and *C. succedana*, especially spring gorse flowering. However, there were seeds produced outside the larval feeding of *C. succedana*. Thus this insect may assist in the biological control of gorse but the assistance of further agents will be required to obtain a desirable control level.

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